Support of Adaptation and Resuscitation of the Newborn Infant

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Abstract: Development and Application of these Recommendations. A working group of the Swiss Society of Neonatology (SSN) first published national recommendations on the care and resuscitation of the newborn infant in 2000. After two revisions (2007/2012), these recommendations are being updated, based on the evidence arising from a critical appraisal of the current scientific publications1), 2) as well as on revised international recommendations2)-4). Additionally, published reflections on these revised international recommendations were taken into consideration (in particular from the ERC and ILCOR) 5)-7) as well as the recommendations from an interdisciplinary group of Swiss medical societies on the organisation of the initial care of the newborn infant, published in 20168). These guidelines should be considered as recommendations that can and should be adapted as the individual situation requires.

Support of Adaptation and Resuscitation of the Newborn Infant

Revised Recommendations of the Swiss Society of Neonatology (2017)

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Introduction

Development and Application of these Recommendations

A working group of the Swiss Society of Neonatology (SSN) first published national recommendations on the care and resuscitation of the newborn infant in 2000. After two revisions (2007/2012), these recommendations are being updated, based on the evidence arising from a critical appraisal of the current scientific publications[1), 2)] as well as on revised international recommendations[2)-4)]. Additionally, published reflections on these revised international recommendations were taken into consideration (in particular from the ERC and ILCOR)[5)-7)] as well as the recommendations from an interdisciplinary group of Swiss medical societies on the organisation of the initial care of the newborn infant, published in 2016[8)]. These guidelines should be considered as recommendations that can and should be adapted as the individual situation requires.

Aim and Target Audience of these Recommendations

These recommendations primarily pertain to the care of neonates with a gestational age GA > 34 0/7 weeks (wks) and with a birth weight (BW) > 2000 g. They apply to both delivery room care and the entire neonatal period. They address all obstetric units in Switzerland as well as all paediatricians, neonatologists, obstetricians, anaesthetists, midwives, emergency-, postnatal ward and neonatal healthcare professionals.

The current revision of 2017 does not contain profound changes compared to the former 2012 version. The following list highlights the main clarifications and pre-emphases[6), 7)].

- Differentiation between procedures to re-establish vital organ functions (resuscitation) and measures to competently and adequately facilitate neonatal adaptation.
- Algorithm: focus on the clinical evaluation of adaptation, maintaining normothermia and avoiding critical delays in initiating measures within 60 seconds («the golden minute»). The 30 seconds rule was dropped, since it is not meaningful nor evidence based.
- Avoidance of hypothermia (since there is a strong association with increased mortality and morbidity) - maintenance of a normal body temperature (target temperature 36.5- 37.5 °C) in the delivery room.
- Delayed cord clamping in the second minute of life.
- Transfer of preterm infants born < 35 0/7 wks GA to a neonatal unit (level ≥ IIA).
- Importance of reliably assessing heart rate as a central parameter to escalate or deescalate resuscitation measures.
- In case of thick meconium stained amniotic fluid and depressed respiration in a newborn, the main focus during the first minute of life is on a rapid initiation of resuscitation efforts to help ventilation and oxygenation, and of positive pressure ventilation. Intratracheal aspiration is only indicated if positive pressure ventilation does not lead to thorax movements or if a tracheal obstruction is suspected.

Organisation

General Aspects

The vast majority of newborn infants without risks do not need any interventions whatsoever during the first minutes of life, except for maintaining a normal body temperature and ensuring a normal adaptation. Yet up to 10% of all neonates require stabilisation measures in terms of simple respiratory support within the first minutes of life. More complex resuscitation measures such as chest compressions, medications and intubation are needed in only about 1% of newborns[2), 9)-13)]. Trained personnel and specific technical equipment must be readily available at every delivery because risk situations cannot always be predicted.

Requirements for Optimal Care of the Newborn Infant:

- Communication between midwives, obstetricians and paediatricians (neonatologists).
- Sufficient information about the risks for the newborn infant, available already before delivery.
- Anticipation of problems that may arise.
- Careful planning and preparation of equipment and briefing of personnel[8)].
- Clear and calm lead and assistance of the resuscitation by a competent professional who is trained in neonatal resuscitation.

Personnel

Ideally, one person is in charge of exclusively caring for the newborn infant after delivery. This person should be able to adequately clinically assess the newly born infant, to ensure normothermia, and if needed, to initiate a resuscitation, i.e. to open the airways and perform bag-and-mask ventilation. For further measures, especially for endotracheal intubation, help from a professional with experience in neonatal resuscitation (neonatologist, paediatrician, anaesthetist) must be requested[14), 15)]. Even after a supposed risk-free delivery, the neonate may present with unforeseen problems. Therefore, every delivery unit needs to provide a well-functioning resuscitation table with specific equipment *(List 1)*, and a person with experience in neonatal resuscitation should be readily available. The primary responsibility for the initial care of the neonate in the delivery room lies with the direction of the obstetric unit[8)]. In individual cases, this

responsibility may delegated to a colleague from a different specialty, preferably to a paediatrician or neonatologist.

A planned home birth or a birth in a birthing centre should be organised such that there is one person caring for the labouring mother and another person with experience in neonatal resuscitation looking after the neonate[2)].

A consensus has defined the framework requirements and the necessary organisation for the interdisciplinary collaboration in order to ascertain the safety of the mother-to-be and her infant[8)]. These recommendations have been ratified by the following societies (Swiss Society of Obstetrics and Gynaecology, Swiss Society of Neonatology; Swiss Society of Paediatrics; Swiss Society of Anaesthesia and Resuscitation, Swiss Association of Obstetric Anaesthesia; Swiss Federation of Midwives) and they are part of this document.

Physicians, midwives, and health care professionals caring for neonates after delivery should attend structured courses in neonatal resuscitation every 2-3 years[16)]. On behalf of the Swiss Society of Neonatology and based on these recommendations, local neonatal centres will organise and run such «start-4neo» courses.

Equipment

Checklists with equipment required for hospital or home delivery are given in the appendix *(Lists 1 and 2)*.

Prenatal Transfer of High-Risk Pregnant Women

Delivery of certain high-risk pregnant women requires specialised knowledge, skills, and equipment in view of optimal care of mother and infant. These requirements cannot be met in all delivery units due to differences in caseload, experience and economic costs. Thus, a small proportion of pregnant women will need transfer to a perinatal centre with a neonatal intensive care unit early enough before a planned or impending delivery.

Indications for Prenatal Transfer

Intrauterine transport of the fetus to a perinatal centre is indicated in all cases of anticipated postnatal need for neonatal resuscitation or neonatal intensive care.

A) Absolute indications for a prenatal transfer include:

- Impending delivery before 35 0/7 weeks of gestation, if no neonatal unit exists within the delivery hospital.
- Impending delivery before 34 0/7 weeks of gestation or estimated birth weight < 2000 g, in case a level IIA neonatal unit is available in the hospital.
- Impending delivery before 32 0/7 weeks of gestation, if a level IIB neonatal unit is present in the hospital[17)].
- Anticipated difficulties in adaptation requiring intensive care.
- Multiple pregnancy (≥ triplets).
- Prenatally diagnosed malformations requiring immediate postnatal intervention.

B) Relative indications include: (if in doubt, and depending on local circumstances, the obstetrical-neonatal centre should be consulted)

- Intrauterine infection.
- Haemolytic disease of the fetus.
- Fetal arrhythmia.
- Intrauterine growth retardation (estimated fetal weight <5th percentile).
- Chronic or unstable illness of the mother (e.g. hypertension, pre-eclampsia, HELLP-syndrome, diabetes mellitus, status post organ transplant, autoimmune disease, etc.).
- Maternal substance abuse.
- Fetus with a lethal malformation where intensive care is not considered meaningful.

Neonatal Adaptation

Introduction

Transition from intra-uterine to extra-uterine life requires a number of biological adaptive steps that are especially important for the integral functioning of the central nervous system. However, delivery and the first days of life are also an emotional event, profoundly influencing the future of the parent-infant relationship. Perinatal care needs to consider these adaptive and emotional processes and weigh them appropriately.

Preparation for Initial Care

1. Anticipation of the Resuscitation Team

- Determine the leader of the initial care/resuscitation.
- Request extra personnel in case of need.

2. Preparation of the equipment

- Check equipment; flow sheet (to document the adaptation and measures taken).
- Alarm scheme must be present in case extra personnel is needed or for alarming the neonatal centre.
- Preheat delivery room (ideally 23 to 25°C).[18)-20)].
- Switch on radiant warmer and light.
- Read maternal medical notes and evaluate if additional experienced personnel might be required.
- Wash hands and wear non-sterile gloves.
- Start Apgar timer or stopwatch after complete delivery of the infant[21)].

Cord Clamping

In vaginally delivered preterm and term neonates who do not require postnatal resuscitation and whose mothers do not need urgent clamping of the cord (e.g. maternal haemorrhage, hemodynamic instability)[22)] placental-neonatal transfusion will be achieved by delayed cord clamping in the second minute after complete vaginal delivery[a), 14), 15), 23)-25)]. A placental-neonatal transfusion can occur even if the infant is positioned on the mother's breast or abdomen[26)]. Late cord clamping does not impede early measures for the infant (drying, stimulating for first breath and immediate mother-infant bonding). Late cord clamping in the term newborn is associated with higher haemoglobin values at birth and better iron-stores during the first months of life, which can have a positive impact on development.[22), 27), 28)]. In preterm infants, late cord clamping is associated with better adaptation (especially with initiation of spontaneous breathing before cord clamping), higher mean arterial blood pressure and higher haematocrit level, as well as with a reduced risk of intracranial haemorrhage[29)-33)]. To date, no recommendation as to the timing of cord clamping can be made for newborn infants needing resuscitation[14), 15)]. More research is needed before milking of the umbilical cord can be declared an alternative for neonates needing resuscitation[34)].

Although long-term advantages have not been proven yet, the cord can be stripped 3-5 times towards the infant in preterm and term infants delivered by Caesarean section[35), 36)]. In case a rapid cord clamping is necessary, there is some evidence for preterm neonates that milking the cord (4 times) before clamping increases the blood volume[37)]. The advantages of cord milking observed with Caesarean section could not be demonstrated in vaginal deliveries; in this situation there is no

a) With regard to delayed cord clamping, the mother's cultural background and her individual wishes should be taken into consideration when determining the actual clamping time. The time point of cord clamping should be recorded on the flow sheet (38).

benefit of an additional cord milking to the delayed cord clamping[37]. The data as to oxytocin application before cord clamping after Caesarean section are not clear in terms of optimal time point, dosing and effectiveness of this measure.

Clinical Assessment of Adaptation

The following 4 criteria are decisive for subsequent initiation of measures for support of transition or resuscitation. Respiration and heart rate are the central criteria in determining further measures; muscle tone and colour are additional criteria to optimise the initial care *(Algorithm)*:

- *Respiration:* Present or absent? Gasping? Usually, healthy term neonates, either spontaneously or after tactile stimulation start breathing or crying within 30-60 seconds following delivery[10].
- *Heart rate:* Should be preferably determined via auscultation using a stethoscope over the apex of the heart. In the first minutes of life and insofar a pulsation is palpable, it can be determined by palpating at the base of the umbilical cord. Is the heart rate above 60 or above 100 beats per minute, respectively? Palpation of peripheral pulses is not appropriate for determining heart rate[39].
- *Tone:* A neonate presenting with very low muscle tone will very likely require respiratory support[15].
- *Skin colour:* Is the infant centrally pinking up (assess the colour of the tongue)? Most neonates are initially pale to cyanotic as fetal SaO2 is around 40-60% and skin perfusion is still diminished. After a few minutes, skin colour changes to a generalised pink. Assessing oxygenation by skin colour can be difficult[40]. Central cyanosis in the presence of anaemia is only visible at very low levels of oxygen saturation. If a neonate remains cyanotic after birth, oxygenation should be assessed using pulse oximetry at the latest with 5 minutes of life[15]. On the other hand, very pale skin colour can be a good indicator of anaemia or acidosis requiring treatment[15].

Apgar Score

The Apgar score is a standardised evaluation of postnatal adaptation and of the success of any resuscitation measures. However, the Apgar score is inappropriate for the immediate decision regarding the use of therapeutic measures.

	0	1	2
Skin colour	Trunk blue or pale	Trunk pink but extremities blue	Completely pink
Respiratory effort*	Absent	Superficial	Good, crying
Muscle tone	Flaccid	Some flexion of extremities	Well flexed extremities
Reactivity**	No response	Slow	Vigorous
Heart rate	0	< 100/Min.	> 100/Min.

Apgar-Score

* Assess respiratory effort in ventilated infants with a dash (–)
** Reactivity: Spontaneous motor activity, crying, sneezing, coughing

At 1, 5, and 10 minutes after complete delivery of the infant, every item of the Apgar score is evaluated and the numbers recorded. In case of clinical changes or after therapeutic measures, additional Apgar scores may be obtained during the 10 minutes following birth or even beyond these first 10 minutes[15]. Except for ventilation *(see*)*, therapeutic measures such as applying oxygen or a support with CPAP don't influence the Apgar score. This means for instance that a centrally and peripherally pink infant under supplemental oxygen receives 2 points for colour.

Procedures during Normal Adaptation

In case of a normal adaptation, neonates breathe spontaneously after delivery, have a heart rate above 100 beats/minute, present with a good muscle tone, and become pink within 5 to 10 minutes following birth[41, 42]. Maintaining a normal body temperature and facilitating the initiation of spontaneous breathing are in the foreground.

- This newborn infant is quickly dried with warmed blankets and is laid on the mother's belly.
- The opening of the airways is ensured by correctly positioning the infant.
- Not every infant needs to be suctioned. If a healthy term newborn infant breathes within the first 60 seconds of life, has a heart rate > 100/min and shows good muscle tone, and if the amniotic fluid is clear, then suctioning of the mouth, pharynx and nose is not warranted. Unnecessary suctioning is uncomfortable for the infant, it can cause damage to the mucous membranes, and even lead to reflex bradycardia and apnoea.
- The Apgar score is assessed at 1, 5 and 10 minutes of life.
- In case of a normal adaptation, the neonate is encouraged to have a first breastfeed shortly after delivery.

Ideally, mother and infant are allowed continuous skin-to-skin contact for 2 hours after delivery; at minimum though until after the first breastfeed. Over this time period, the attending midwife or nurse should periodically check up on the well-being of the infant[43]. It is of particular importance to check that the mouth and nose are not obstructed when a baby is placed on the mother's chest. Routine procedures and further care of the infant should be performed about 2 hours after delivery, or after the first breastfeed at the earliest[44]. These procedures include a first general exam by the midwife, obstetrician, paediatrician, or neonatologist. This exam should be done under a radiant warmer in good lighting conditions.

The purpose of this first exam is to assess the further adaptation based on the vital parameters, and the body measurements, as well as to exclude potential malformations:

- **Body measurements:** weight, length, head circumference (plot values on a growth chart[45]).
- **Respiration:** respiratory rate (normal range, 30-60 breaths/minute). Are there signs of respiratory distress (retractions, grunting, flaring, cyanosis, tachypnea)?
- **Circulation:** heart rate (normal range 100-160 beats/minute). Is the periphery warm and well perfused?
- **Thermoregulation:** the target temperature range for newborn infants without need of therapeutic hypothermia is: 36.5-37.5°C. Assessment of rectal temperature allows for early diagnosis of anal atresia.
- **Malformations:** extremities, genitalia, the back, palate. Placement of a gastric tube to exclude oesophageal atresia or an upper intestinal obstruction is only warranted in case of polyhydramnios, foamy salivation, or respiratory distress. Routine probing of nasal airways to rule out choanal atresia must be avoided. All observations and measures need to be recorded on the baby's flow chart.

- The skin is cleared of all blood and meconium without completely wiping off the vernix.
- The vitamin K prophylaxis, and the active and passive hepatitis B vaccination are performed according to current guidelines[46),47)]. Prophylactic silver nitrate or other disinfecting eye drops to prevent neonatal gonococcal ophthalmia are no longer recommended in Switzerland.

Procedures in Case of Impaired Adaptation

Resuscitation algorithm

If clinical assessment shows no regular or insufficient breathing or a heart rate below 100 beats/minute, further procedures are performed in addition to the aforementioned measures for a normal transition, namely thermoregulation (T), opening airways *(A, airways)* and further measures, depending on the condition of the infant. Opening, respectively maintaining the airways open *(A)* and enabling the aeration of the lungs *(B, breathing)* are the two most important measures in neonatal resuscitation. In most cases, these measures are sufficient to stabilise a neonate. Further, more complex interventions are ineffective until those two initial measures are correctly established[15)]. The potential steps and their respective indications are summarised in the *Algorithm*.

Commentary on the Individual Steps

T - Thermoregulation

- Independently of gestational age, there is a clear association between hypothermia and mortality as well as morbidity[4),19)].
- Resuscitation should be performed in a heated room (target room temperature, 23-25°C) [18)-20)]. Draughts should be avoided; windows and doors should be closed.
- The radiant heater should be switched on 10-15 minutes ahead of the delivery.
- The infant should be quickly dried and transferred in warm blankets to the resuscitation table under a radiant warmer; wet blankets should immediately be replaced by dry and warm ones. A non-heatable pad draws warmth from the newborn infants. It should thus be covered with warm blankets.
- Further possible measures: head cover (cap or bonnet), switching on the heating pad or mattress.

A - Opening the airways

Correct Positioning (Figure 1)

- A correct horizontal supine placement of the infant, with the head in neutral position with slight extension, is important to maintain optimal airway patency. Hyperextension or flexion of the head should be avoided, for this may lead to airway narrowing.
- A small bolster under the shoulders (not under the occiput/neck) helps in maintaining airway patency.
- Positioning of the infant in a traditional Trendelenburg's position provides no advantages in terms of lung function, thus, it should no longer be performed[48)].

Suctioning

- Suctioning is only indicated when amniotic fluid, secretions or blood obstruct the airways or when ventilation becomes necessary.
- Use a 10 Ch (Charrière) gauge catheter without side perforations. Use a suction device (oral suction device, mechanical suction device) with a trap (set negative pressure to about –2 m water column = –200 mbar = –150 mm Hg = –20 kPa = –0.2 atm).
- Suction the mouth and, if necessary, both nostrils.
- Do not insert the catheter into the nose because of risk of injury and swelling of mucous membranes. Newborn infants are preferential nose breathers.
- Repeated suctioning of longer duration impedes the initiation of spontaneous breathing. Touching the oropharynx can lead to a vagal reflex with bradycardia.
- Any suctioning manoeuvre should last less than 5 seconds. Suctioning of the stomach should only be performed when adequate oxygenation and stable respiration are achieved, and under the following circumstances:
  > In case of polyhydramnios, or when foamy saliva is present.
  > During or after longer lasting bag-and-mask ventilation or before a transfer.
- If the suction catheter cannot be advanced into the stomach, oesophageal atresia is highly suspected. In that case, the infant should be positioned prone, and mouth and pharynx regularly and cautiously suctioned with an open naso-gastric tube in place.
- Suctioning of more than 20 ml of gastric fluid is suggestive of upper gastrointestinal obstruction. In this situation, a gastric tube should be put in place, the end left open and suctioned every 10 minutes.
- Meconium stained amniotic fluid: Intrapartum oropharyngeal suctioning in presence of meconium stained amniotic fluid has no influence on the outcome of the neonate[49)-51)]; this procedure is therefore no longer recommended as routine measure[52)].
- The care of the newborn infant with meconium stained amniotic fluid follows the same principles as for infants with clear amniotic fluid. This case however requires that a person being competent in neonatal resuscitation and intubation is both informed and available. Vigorous newborn infants with normal breathing pattern and with a good muscle tone may remain with their mothers. In case of thick meconium stained amniotic fluid and depressed respiration, the infants shall not be routinely suctioned intratracheally since this does not prevent meconium aspiration[53),54)]. The main focus should rather be on rapidly initiating the usual resuscitation measures to support respiration.
- Provided the caregiver has the necessary skills and the needed equipment is available, the intratracheal suctioning should only performed if: 1) the usual measures to free the upper airways are not successful, or 2) if there are no thoracic movements during positive pressure ventilation and a tracheal obstruction is suspected. For that purpose, the infant is intubated endotracheally. Tracheal suctioning is performed by connecting the meconium aspiration adapter between the endotracheal tube and the suction source, then the endotracheal tube is withdrawn under suction *(Figure 2)*. The Kurtis Meconium Suction System® can be used as an alternative. Suctioning the thick meconium through the endotracheal tube using a catheter is not sufficient. This procedure of intubation, tracheal suctioning, and extubation can be repeated provided the heart rate remains normal. Otherwise, one should proceed to efficient ventilation using bag and mask, especially with persistent bradycardia[14),15)].

Assessing Heart Rate

- Reliably assessing the heart rate (HR) is of central significance in neonatal resuscitation, since on the one hand, the HR will determine changes or the escalation of resuscitation measures, on the other hand an increase or a stable HR >100/min will be the most important parameter determining a successful resuscitation.
- Initially, the HR is most easily assessed with a stethoscope placed over the apex of the

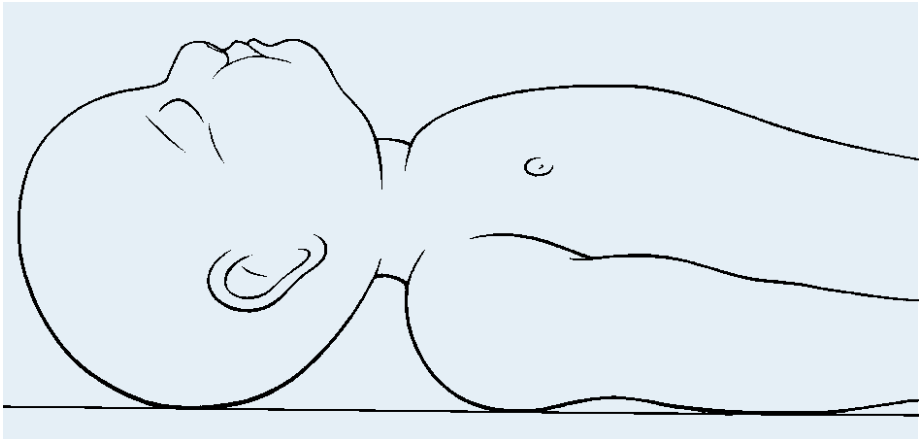

Figure 1: Correct positioning for maintaining airway patency

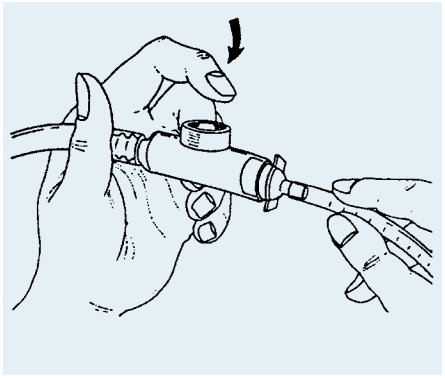

Figure 2: Meconium aspiration adapter (Neo-Tech® Meconium Aspirator) for intratracheal meconium suctioning[55].

heart.
- Palpating the base of the umbilical cord is meant as an auxiliary measure. It is quickly done but less reliable.
- Both above mentioned methods can lead to underestimating the HR by about 20 beats/min[56),57)] and thus possibly lead to unnecessary resuscitative measures.
- Using pulse oximetry to determine the HR is more precise but needs 1-2 minutes to establish accurate readings[58)]. Pulse oximetry often underestimates the HR during the first few minutes of life[59)].
- Use of ECG to measure the HR is precise and reliable already within the first minutes of life.[58)-60)]. Applying ECG leads should neither delay the clinical assessment nor the initiation of resuscitative efforts.

B - Breathing / Ventilation *(Figures 3 and 4)*

With insufficient or absent spontaneous breathing or gasping, or with a heart rate <100/min, the newborn infant should be ventilated via bag-and-mask. The head is in midline, slightly extended, and the mouth is held minimally open. In term neonates, assisted ventilation is initiated with room air[14),15)].The first 5 inflations should be prolonged to 2-3 seconds (maximally to 5 seconds) in order to support the expansion of the lungs[2),7),61)]. This can be achieved using a so-called «flow inflating bag» or using a T-piece resuscitator, but not with a self-inflating bag. Inspiratory pressure is monitored by observing the thorax excursions and measured using a manometer attached to the bag; often, an inspiratory pressure of 20-30 cm H_2O is sufficient. Occasionally, inspiratory pressures of 30-40 cm H_2O are required in term neonates. If monitoring of inspiratory pressure is not possible, inspiratory pressure should be adjusted such that visible thorax excursions and an increase in heart rate are achieved[14),15)]. Further ventilation is accomplished with pressures adjusted to the requirements of the infant (visible thorax excursions, increase in heart rate?) and using a ventilation rate of 40-60/min. Although clinical studies specifically addressing the additional use of positive end-expiratory pressure (PEEP) during positive pressure ventilation to establish functional residual capacity immediately after birth are lacking, PEEP is likely to be beneficial and should be used if appropriate equipment is available. As a rule, PEEP is started at a pressure of 5 cm H_2O. If a self-inflating bag is used, an additional PEEP-valve needs to be added[14)].

Ventilation with a T-piece system[62)-64)]: In contrast to a bag-and-mask system[65),66)] the use of a T-piece system achieves a more reliable and stable application of a PEEP pressure; furthermore, inspiratory pressure and inspiratory time can be more readily controlled. Contrary to the self-inflating bag, the T-piece system allows applying a prolonged inspiration or performing a CPAP therapy. When using a T-piece system, a bag and mask should always be at hand as a backup.

Response to assisted ventilation is assessed by the following criteria:
- Visible thorax excursions.
- Most important sign of success: heart rate increases above 100/min or remains >100/min.
- Skin color changes to pink.

Assisted ventilation is continued until the neonate establishes regular and sufficient spontaneous breathing. If continued bag-and-mask ventilation is necessary, a gastric tube should be inserted to allow shunted air to evacuate from the stomach[55)]. The efficacy of a laryngeal mask airway has been shown in term newborn infants and in preterm infants born ≥ 34 weeks GA and with a birth weight > 2000g[67),68)]. Thus, trained personnel, especially in situations where bag-and-mask ventilation or intubation have failed, can consider the laryngeal mask as an alternative for ventilating term newborn infants[b) 14),15),39),69)]. In most instances, however, bag-and-mask ventilation will be effective; moreover, acquiring this skill of assisted ventilation technique is easier. If necessary, oral insertion of a Guedel tube or nasal insertion of a Wendel tube can be considered (e.g. Pierre-Robin sequence, choanal atresia).

The Role of Oxygen in Neonatal Resuscitation

Recent data question the use of pure oxygen (FiO_2 100% O_2) in newborn resuscitation, for lower oxygen concentrations or room air (FiO_2 21%) have proven just as effective as oxygen in high concentrations[70)-73)]. There is concern with regard to the possible effects of applying 100% oxygen on respiration, cerebral perfusion, and to the potential cell-damaging effects caused by oxygen radicals, especially when high concentrations of oxygen are given following a hypoxic event associated with cell and tissue injury. In general terms, oxygen ought to be considered a medication whose indication and dosage should be strictly regulated. The large majority of newborn infants do not require supplemental oxygen immediately after birth. Isolated peripheral cyanosis in an otherwise vigorous newborn with normal heart rate is not an indication for supplemental oxygen application.

b) Laryngeal mask is not indicated in preterm infants < 34 gestational weeks, or a birthweight < 2000g during cardiac massage.

Recent data show that preductal transcutaneous oxygen saturation during normal transition in healthy term neonates rises from 40-60% to > 90% within 10 minutes after birth *(Algorithm)*[74)-79)]. Oxygen should be dosed properly and always be monitored via preductal transcutaneous pulse oximetry ($tcSaO_2$ on the right hand/wrist). Target $tcSaO_2$ under supplemental oxygen should be 90-95% (increase FiO_2 if $tcSaO_2$<90%, decrease if $tcSaO_2$>95%).

Neonates not requiring resuscitation

In case a newborn infant has central cyanosis after 5 minutes of life associated with regular breathing and normal heart rate, his preductal transcutaneous saturation should be assessed. If the saturation is too low (see algorithm) the infant should be administered oxygen via a face mask (flow 4-5 L/min, initial FiO_2 30-40%). The face mask should be placed evenly over mouth and nose with a proper seal. Unnecessary movements back and forth of the mask will lead to fluctuations in oxygen concentration. Oxygen concentration is increased in increments of 10% until a normal oxygen saturation is obtained.

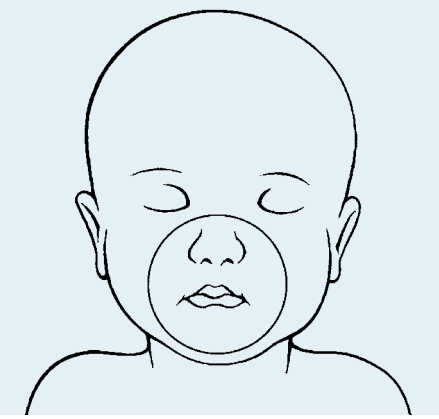

Figure 3: Correct positioning of the face mask.

Figure 4: Bag-and-mask ventilation. Caution: the thumb and the forefinger form the so-called C-grip, the middle finger should be placed on the jaw without putting pressure on the floor of the mouth. Mouth is slightly opened.

Neonates requiring resuscitation

Assisted ventilation in term neonates should be initiated with room air. If a neonate shows insufficient breathing in presence of a normal heart rate, inspired oxygen concentration should be adjusted depending on $tcSaO_2$ (measured by preductal pulse oximetry). If cyanosis persists in presence of a normal heart rate, supplemental oxygen should be titrated such that oxygen saturation increases normally *(Algorithm)*[c) d), 14), 15)]. On the other hand, if bradycardia persists despite adequate ventilation for 30 seconds, supplemental oxygen concentration should be increased to 100% within a short period and extra help sought.

C- Circulation and Chest Compressions *(Figures 5a-c)*

Adequate ventilation is the most important measure in initial resuscitation of the neonate in order to provide oxygen to the coronary arteries and to the brain; if assisted ventilation is insufficiently performed, chest compressions will be ineffective[15)]. Chest compressions are very rarely necessary in neonatal resuscitation (<1:1000 deliveries).

Indications for chest compressions include:

- Absent heart sounds (asystole) [e)].
- Bradycardia less than 60 beats/min despite adequate ventilation with a FiO_2 of 100% for 30 seconds.

Compression technique[85)]: Both thumbs are placed side by side or superimposed beneath a virtual line drawn between both nipples *(Figures 5a and 5b)*, with fingers encircling the thorax. Compression depth should be at least 1/3 of the antero-posterior diameter of the thorax *(Figure 5c)*. Chest compressions can impede effective ventilation, which is why both actions should be coordinated to avoid simultaneous delivery[14), 15)]. There should be a 3:1 ratio of compressions to ventilations during the neonatal period (up to 4 weeks post expected date of delivery), to achieve 90 compressions and 30 breaths per minute. Usually a compromised gas exchange with hypoxemia is the primary cause of a cardiovascular collapse in this age group, which is why more ventilations may be applied to overcome the hypoxia[2), 7)]. This ratio should be continued even after intubation. Assisted ventilation should be performed with 100% O_2. Heart rate should be measured 30 seconds after initiation of cardiac massage and be re-evaluated in 30 second intervals. Cardiac massage can be stopped when spontaneous heart rate is > 60 beats/minute[15)].

Stepwise Course of Action and Time Line in Case of Bradycardia *(Algorithm)*

1. Heart rate between 60-100/Min: initiate positive pressure ventilation with 21% O_2
2. Heart rate remains between 60-100/Min despite adequate ventilation with 21% O_2 for 30 seconds: continue ventilation, quickly titrate O_2 to 100% and call for help.
3. Heart rate sinking/unchanging < 60/Min despite adequate ventilation with 100% O_2 for 30 seconds: coordinate ventilation with 100% O_2 and thorax compressions.
4. Heart rate remains < 60/Min after further 30 seconds despite adequate ventilation with 100% O_2 and chest compressions: apply adrenalin iv and eventually intubate.

Endotracheal Intubation *(Figure 6, Table)*

The indication for an intubation depends on the gestational age, the clinical situation, the extent of respiratory depression, the efficacy of bag-mask ventilation or the presence of certain malformations (i.e. diaphragmatic hernia). Only a trained person should perform an intubation. Oro-tracheal intubation is more rapid and easier to perform than naso-tracheal intubation, and this should therefore be the preferred method to overcome acute hypoxaemia and/or bradycardia. Nasal intubation permits better fixation in case of a potential transport, but technically it is more challenging than oro-tracheal intubation and should not be undertaken in case of acute hypoxaemia. If the person

c) Based on animal experimental data, newborn infants with pulmonary hypertension or with malformations such as pulmonary hypoplasia (oligohydramnios, diaphragmatic hernia) might profit from higher oxygen concentrations. However, data are too scarce to make general recommendations for this purpose[78)].

d) Hyperoxaemia is harmful for preterm infants and can occur at oxygen saturation values > 95%. For this reason, the postnatal increase in oxygen saturation in preterm infants should not exceed that seen in term infants. Although the data are not fully clear yet, additional oxygen immediately after birth may be necessary and beneficial in preterm infants[80)-82)], but should always be carefully titrated.
The use of a pulse oximeter should be considered in every delivery when a disturbed adaptation, respiratory support or need for resuscitation can be expected for a newborn infant[39)]. Modern devices allow a reliable and continuous assessment of the oxygen

doing the resuscitation is not trained in intubation, bag-and-mask ventilation should be continued until a person skilled in neonatal intubation arrives on the scene. During intubation the heart rate should be monitored. An intubation should be interrupted in case of bradycardia, or in case of an unsuccessful attempt after 30 seconds at the latest.

Correct positioning of the endotracheal tube must be verified after each intubation. In most cases, this can easily be accomplished by clinical assessment (visually during intubation, rapid rise of heart rate and oxygen saturation, humidity in the tube, thorax excursions, symmetrical air entry on auscultation of the lungs). Measurement of expiratory CO_2 (e.g., using a colorimetric device) is easy and rapidly achieved; it is the gold standard for confirming endotracheal intubation, but does not rule out single lung intubation[f), 14), 15), 86)].
With an indwelling endotracheal tube, the infant should always be ventilated with a positive pressure and a PEEP of 5 cm H_2O. Spontaneous breathing with an indwelling tube without applying a PEEP can lead to atelectasis and must thus be avoided.
Preterm infants intubated right after delivery should remain so for transport to the neonatal unit. In rare circumstances, term neonates may be extubated in the delivery room by the transport team if the cardio-pulmonary situation has normalised, the infant is pink (pulse oximetry) and blood gas analysis is normal.

Therapeutic Hypothermia

Neonates ≥ 35 0/7 weeks GA and ≤ 6 hours old with severe neonatal acidosis (pH ≤ 7.0 obtained within the first hour of life; base deficit ≥ -16 mmol/L and/or blood lactate ≥ 12 mmol/L) and clinical evidence of moderate to severe hypoxic ischaemic encephalopathy are to be treated with therapeutic hypothermia[87), 88)]. This significantly improves survival and neurological outcome[89)]. Such treatment should, however, only be performed in a neonatal intensive care setting using strict criteria and following a rigorous protocol[15)]. Hyperthermia should always be avoided. The therapeutic window being open within the first 6 hours after birth, external heat sources may be shut off and the neonate may be undressed in the referring hospital prior to arrival of the transport team, yet only after prior consultation with the neonatal referral centre[90)]. These measures should not impair initial stabilisation and resuscitation of the neonate, they are, however, important for further care of the child[15)]. No active cooling measures should be installed (e.g., ice packs) given that these ice packs may rapidly lead to hypothermia. Rectal temperature should be measured every 15 minutes until arrival of the transport team; the target temperature is 34-35°C. If rectal temperature falls below 34°C, the infant should be covered with a blanket or other warming measures should be applied to avoid further temperature decrease; the temperature should be checked again after 15 minutes. Cooling during transport is performed according to the national transport protocol[91)].

saturation and heart rate from the first minutes of life [83)]. The sensor is applied to the right hand or right lower arm, thereby allowing a precise measurement of the preductal oxygen saturation[76), 79)]. A faster signal acquisition can be obtained by applying the sensor to the infant first, and afterwards connecting it to the device; with this sequence a reliable measurement can be obtained in most cases within 90 seconds[84)].

Volume Expansion and Buffering

Venous Access

An intravenous access is mandatory for intubated neonates or in case of cardiopulmonary instability. Umbilical catheterisation is the best option for urgent situations or in presence of shock *(List 1)*. Once the cardiovascular system has been stabilised, continuous infusion with glucose 10% is begun at a rate of 3 ml/kg/h, which is equivalent to a glucose supply of 5 mg/kg/min.

Volume Expanders

If signs of hypovolaemia or cardiovascular compromise are present (as indicated with poor peripheral perfusion, week pulses, pallor, low blood pressure and tachycardia), volume expansion must be applied over 5-10 minutes. The following solutions come into consideration:

- NaCl 0.9%: dosage initial dose 10 ml/kg, to be repeated depending on blood pressure and clinical signs.
- Packed red blood cells (in case of acute anaemia, history of bleeding): use untested O Rh negative blood. Dosage: 10 ml/kg, to be repeated if necessary. 0.9% NaCl should be given i.v. to bridge the time until transfusable blood is available.

Albumin 5% is no longer recommended as a volume expander for neonatal resuscitation[92)].

Buffering

In the presence of metabolic acidosis, the aim is to treat the primary cause. Sodium bicarbonate administration can lead to significant

Figure 5a: Chest compressions (both thumbs placed side by side). Caution: Thumbs should be flexed at the distal joint to enable vertical pressure on the thorax and thereby compression of the heart between sternum and vertebral column.

Figure 5b: Chest compressions (thumbs superimposed).

Figure 5c: Chest compressions (compression phase). Caution: Apply sufficient pressure in order to reduce the antero-posterior thorax diameter by a third.

side effects (paradoxical intracellular acidosis, osmotically induced myocardial dysfunction, diminished cerebral perfusion, and cerebral haemorrhage especially in preterm infants). There is no evidence for the efficacy of sodium bicarbonate in the initial resuscitation of a neonate, it is therefore no longer recommended in the initial phase of resuscitation[39), 93)-96)].

Drugs *(Table)*

Drugs are rarely needed during neonatal resuscitation; if anything, then volume expanders or adrenalin (epinephrine) are primarily used[14), 39)]. Bradycardia after delivery is usually caused by an important hypoxia, which results from inadequate lung ventilation[15)]. Thus, an adequate oxygenation is a pre-condition for a successful use of drugs[83)].

Adrenalin 1: 1000 (1 mg/mL)[g)]

If the heart rate remains below 60 beats/min despite effective ventilation with 100% oxygen and with chest compressions for at least 30 seconds, administration of adrenalin is reasonable[15)]. Adrenalin should be given intravenously if feasible[9)].

Intravenous dosage: 10-30 µg/kg/dose IV (corresponds to 0.1-0.3 mL/kg of a 1:10,000 adrenalin solution; 1 mL of a 1:1000 adrenalin solution + 9 mL of 0.9% NaCl).

Intratracheal dosage: 50 to maximum 100 µg /kg/dose[14), 15)].

Naloxone (0.4 mg/mL)

There is no evidence to support the use of naloxone to reverse neonatal respiratory depression at birth caused by opioids. Further, it is unknown if naloxone can reduce the need for mechanical ventilation in the delivery room. Long-term safety is questionable, too; therefore, naloxone cannot be recommended routinely in respiratory-depressed newborn infants in the delivery room[97)]. First line treatment includes respiratory support and mechanical ventilation.

Possible indication for naloxone: Newborn infants whose mothers have received opioids within 4 hours prior to delivery. Dosage: 0.1 mg/kg IV or IM (not to be given endotracheally or subcutaneously)[h)]. The half-life of naloxone is usually shorter than that of opioids, which is why infants must be monitored during the first 24 hours, and needs to be transferred to a neonatal unit (level IIA or higher).

Contraindication: Infants of opioid dependent mothers (check history!).

Care of the Parents

Parental support during the delivery is an important task that is particularly challenging when the newborn infant shows an abnormal adaptation or is born with malformations. Resuscitation often requires a considerable amount of attention, thus impeding mother-infant interaction. Nevertheless, parent-infant contact should be encouraged at all times, even in difficult situations.

Most parents witnessing a resuscitation experience fear and negative feelings. In the immediate acute situation, resuscitation efforts cannot be explained and discussed with the parents. Their presence can lead to additional stress and distraction to the resuscitation team. If the newborn infant is resuscitated in a room separate from the parents, it is important that the resuscitation team keeps them regularly up-dated regarding the situation of their infant and regarding the measures taken[15)]. Ideally one dedicated person, who is not directly involved in the resuscitation should serve as the go between.

The best-case scenario is to brief the parents before delivery on the probable postnatal course of care and on possible postnatal complications. Parental presence during a possible resuscitation can also be discussed at that time[99)-102)].

After a difficult resuscitation, there should be sufficient time for parental briefing, and for the parents to see and touch their child. Before transferring the infant to the neonatal centre, his/her photo should be taken and handed over to the parents. The parents should also receive the address and telephone number of the neonatal unit as well as the name of a contact person. Mother and nurses need to be reminded that the milk production should be stimulated by regular pumping even in a critical situation. Further and in consultation with the local gynaecologist, the mother's transfer to maternity ward of the receiving hospital should be broached.

Also, the team involved in the resuscitation should have the opportunity on-site or within a short time to undergo a debriefing, eventually together with members of the responsible neonatal team.

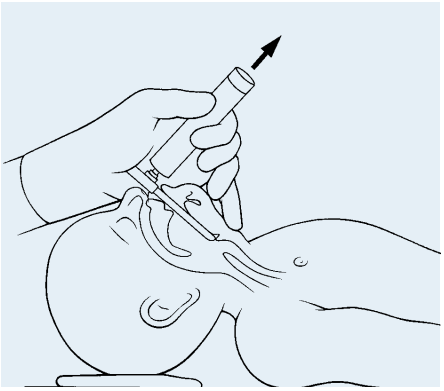

Figure 6: Oro-tracheal intubation.

Discontinuation of Resuscitation

If despite continuous and appropriate resuscitative efforts over 20 minutes with effective ventilation at 100% O_2, coordinated chest compressions and intravenous adrenaline[7), 103)-105)] the newborn infant does not show any vital signs (no cardiac activity, no spontaneous breathing, an Apgar score remaining at 0)[6)], discontinuation of resuscitation may be justified, for survival becomes very unlikely or is most likely associated with very severe neurologic disability[14), 39), 106), 107)]. Auscultation of heart rate can be very difficult in these circumstances; pulse oximetry or ECG-monitoring will allow a more reliable assessment of the heart rate. In case of uncertainty, resuscitation should be continued until a physician trained in neonatal resuscitation arrives on the scene, and a concerted evaluation should be performed before discontinuing resuscitative efforts. After discontinuation, the neonatal unit should be contacted to arrange potential further exams.

e) The use of a pulse oximeter or of an ECG during chest compression is beneficial. If ECG leads are readily placed, this means of measuring heart rate is superior to that of pulse oximetry. The latter takes longer to establish a reliable pulse signal and sometimes underestimates the actual heart rate[59)]. Assessing heart rate by palpating the base of the umbilical cord during thorax compressions is unreliable.

f) Little data exist regarding the measurement of expiratory CO_2 in neonatal resuscitation. Nevertheless and in addition to the clinical assessment, the proof of CO_2 in the expiratory air represents a useful method to confirm the intratracheal position of the endotracheal tube[4), 14), 15)] ; whereas a negative result indicates an esophageal intubation. The result of this measurement can be false negative in case of low lung perfusion. Contamination of the colorimetric device with surfactant, adrenalin or atropine can lead to a false positive result[39)]. In this case however and in contrast to a successful intubation, the colour signal does not change synchronously with in- and expiration but shows a permanent colour change.

Care of the neonate following resuscitation

The condition of neonates having required resuscitation may deteriorate again at a later stage. Therefore and after establishing adequate ventilation, oxygenation, and circulation, these infants should be transferred to a neonatal unit (Level IIA or higher) allowing for continuous monitoring, observation and care[14), 15)].

Laboratory Tests in the Delivery Room

Clinical assessment of adaptation can be complemented by the following «laboratory-triad»:

- Blood gas analysis (especially in case of low 5- and10 min Apgar scores)
- Haematocrit
- Blood sugar level

Blood gas analysis is necessary if umbilical artery pH is <7.15 and in the presence of clinical signs of abnormal adaptation.

Haematocrit should be determined when suspecting polyglobuly (post term, dysmaturity, or peripheral cyanosis) or anaemia (pallor, circulatory instability).

In the delivery room, *blood glucose levels* are determined only if symptoms suggestive of hypoglycaemia are present, after resuscitation or in case of diabetic fetopathy. Low blood glucose levels are common during early postnatal transition. Thus, measurements of blood glucose levels within the first 2-3 hours of life in asymptomatic newborn infants with normal birth weights are misleading and clinically meaningless[108)]. Hypoglycaemia is to be avoided in neonates with hypoxic-ischaemic encephalopathy (normal blood glucose levels 3.0 to 4.5 mmol/L)[109)].

Postnatal Transport of High Risk Newborn Infants

Whenever possible, a neonatal transport should be avoided. Instead, one should strive for a prenatal transfer of the pregnant mother to a perinatal centre with a neonatal intensive care unit.

Indications for Neonatal Transfer of Newborn Infants to a Neonatal Unit (Level IIA or higher):

- Preterm infant below 35 0/7 weeks GA.
- Birth weight less than 2000 g.
- Severe metabolic acidosis (pH < 7.0, base deficit ≥ -16 mmol/L and/or lactate ≥ 12 mmol/L), independently of the clinical situation (Level III).
- Neonates ≥ 35 0/7 weeks GA with clinical signs of hypoxic ischaemic encephalopathy (see above) after prior consultation with the neonatal referral centre (Level III) for therapeutic hypothermia as early as possible (within 6 hours of birth).
- Neonates after resuscitation (bag and mask ventilation > 5 min, intubation, volume expansion, chest compressions, medication etc.).
- Cardio-pulmonary disturbances lasting more than 4 hours post-delivery.
- Persistent or recurrent hypoglycaemia (<2.5 mmol/L with a bedside test) despite early feeds[108)].
- Suspected neonatal infection (no antibiotics to be given orally or intramuscularly)[110)].
- Seizures, symptoms of drug withdrawal.
- Jaundice at birth[111)].

This list is not exhaustive; special and unclear situations should be discussed with the perinatal/neonatal centre. Newborn infants should be transported by trained neonatal transport teams using transport incubators.

Checklist before transport:

- Mother's and infant's data, resuscitation flow sheet.
- Maternal blood (10 mL EDTA blood) and cord blood.
- Placenta.
- Show infant to mother/parents before departure.
- Provide the parents with the address and telephone number of the neonatal unit.

List 1

Equipment for a Delivery in a Hospital Setting

Inventory of the Resuscitation Equipment

- Mobile resuscitation unit or fixed resuscitation place
- Radiant warmer, warm and draught-free environment.
- Connections for electricity, oxygen/ compressed air[i)] and suction.
- Work surface and space for material.
- Stop watch/Apgar timer.
- Access for the transport incubator.
- Non-sterile examination gloves (sizes S, M, L).

Lighting

- Bright light, preferably integrated within the radiant warmer.

Heat Sources

- Overhead radiant warmer with a fixed distance to the pad (do not use red light heater).
- Sufficiently warmed blankets/ diapers.
- Preheat resuscitation place early enough.

Suction Device

- Mouth-held suction device with a collection container.
- Suction device with negative pressure set at –200 mbar (-20 kPa, ca. - 0.2 atm, -2 mH_2O, -150 mmHg).
- Suction catheter and tubing connectors.
- Meconium adaptor for intratracheal suctioning *(Figure 2)*.
- Suction catheters sizes 8 and 10 Ch (rounded tip, no side ports).

Oxygen and Gas Supply

- Oxygen source with flow meter, blender for compressed air/oxygen[i)], tube to face mask/ ventilation bag.
- Compressed air.
- Pulse oximeter[j)].
- Oxygen face mask.

Equipment for Ventilation

- Ventilation bag with a reservoir and a PEEP-valve; plus one extra bag in reserve[k)].
- Face masks (sizes 00 and 01); plus one extra set in reserve.
- Optionally, a T-piece ventilation system.
- Laryngoscope, blade sizes 0 and 1; plus additional bulbs and batteries.
- Endotracheal tubes: sizes 2.5 / 3.0 / 3.5 (mm internal diameter) for oral (with guide wire) and nasal intubation.
- Magill forceps.
- Adhesive tape.
- Stethoscope for infants.
- Guedel tube sizes 00/ 000, optionally Wendl naso-pharyngeal tubes.

g) No studies in newborn infants exist on high dose adrenalin application (100 µg/kg/dose)[96)]. For this reason, and because of potential side effects, this high dosage is not recommended. Although during neonatal resuscitation intubation is usually performed before a venous access (umbilical venous catheter) is placed, the intravenous application of adrenalin should be preferred over the intratracheal route whenever possible. If an intratracheal adrenalin application remains ineffective, it should be repeated intravenously. If adrenalin is repeatedly given intravenously, the normal dosage should be chosen[14), 15)].

h) The AAP recommended dosage of naloxone of 0.1 mg/kg is not evidence based[98)].

Endotracheal Tube			2 kg 34 wks GA	3 kg 37 wks GA	4 kg 40 wks GA
Tube size			ID 3.0	ID 3.5	ID 3.5
Insertion depth at lip (cm)			8	9	10
Insertion depth at nose (cm)			9.5	10.5	11.5
Medication	**Dose**	**Preparation/Indication**	**2 kg 34 wks GA**	**3 kg 37 wks GA**	**4 kg 40 wks GA**
Adrenalin 1 : 1000 (1mg/mL vial))	Intravenously: 10–30 µg/kg	1 ml + 9 ml NaCl 0.9% (1 : 10 000 i. e. 1 mL = 100 µg)	0.2–0.6 ml	0.3–0.9 ml	0.4–1.2 ml
	Intratracheally: 50–100 µg/kg i.tr.		1–2 ml	1.5–3 ml	2–4 ml
NaCl 0.9%	10 ml/kg	Volumene bolus	20 ml	30 ml	40 ml
Glucose 10%	4–6 mg/kg/Min. 2 ml/kg	Glucose infusion Symptomatic hypoglycaemia	6 ml/h 4 ml	9 ml/h 6 ml	12 ml/h 8 ml

Material for Venous Access

Peripheral Lines

- Venous in-dwelling catheters (e.g. Insyte BD 24G, Neoflon BD 26G).
- Three-way stopcock.
- Extension (special paediatric size).
- Band-aid.
- Splint.
- 10 mL, 5 mL, 2 mL and 1 mL syringes; 5 syringes for each size.
- Needles (18 G).

Umbilical Venous Catheter

- Sterile gloves, different sizes.
- Disinfectant (containing either alcohol or octenidin-phenoxyethanol), sterile swabs.
- Sterile single-use umbilical catheter tray (e.g. Vygon®): Umbilical tape, slit/fenestrated sterile drape, 2 Péan clamps, fine and rough anatomical forceps, 1 surgical forceps, scissors, needle holder, scalpel, suture (e.g. Mersilene Ethicon® 2.0 or 3.0 with atraumatic needle).
- Umbilical vein catheter 3.5 and 5 Ch.

Umbilical Vein Catheter Placement

1. Have assistant hold umbilical cord up.
2. Disinfect abdominal skin around the umbilical stump and umbilical cord.
3. Lay down umbilical cord.
4. Place sterile slit/fenestrated drape on the infant, cord stump remains visible and allowing for the infant to be observed.
5. Place sterile umbilical tape around the cord stump with a loose knot.
6. Using the sterile blade, cut off cord stump 1 cm above the umbilical insertion.
7. Locate the umbilical vein and the two umbilical arteries *(Figure 7)*.
8. Using the Péan clamps to stabilise the stump, clamp the Wharton's elly and insert the umbilical venous catheter (usually 5 Ch), which has been flushed with 0.9% NaCl beforehand *(Figure 8)*.
9. The catheter should be advanced to the appropriate depth according to the size of the infant. In an emergency situation, a depth of 4-5 cm is sufficient (check by aspirating blood).
10. Suture catheter to Wharton's jelly (do not suture to the skin), this is ideal in case of a transport.

Further Equipment

- Umbilical cord clamps.
- Gastric tubes, sizes 6 and 8 Ch.
- Venous in-dwelling catheters for drainage of a pneumothorax (e.g. Venflon Pro® BD 18 G or 20 G).
- Tape measure.
- Thermometer.

Fluids

- Glucose 10%, 100 mL bottles and 10 mL vials.
- NaCl 0.9%, 100 mL bottles and 10 mL vials.

List 2

Minimally Required Equipment for a Home Delivery and for a Delivery in a Birthing Centre

- Telephone numbers (numbers of responsible neonatal unit and of obstetric unit, of local ambulance & transport service for newborn infants at hand).
- Heated room and good lighting conditions.
- Table with padded surface at table height.
- Towels (preheated) and gloves.
- Mouth-held suction device.
- Ventilation bag (e.g. Baby-Ambu- or Laerdal-bag, with reservoir) as well as masks (Laerdal masks sizes 00 and 01).
- Oxygen face mask and oxygen connecting tube.
- Oxygen bottle with a flow meter (flow of up to 6-10 L/min).
- Plastic wrap.
- Pulse oximeter.
- Resuscitation flow sheet.
- Cord clamp, cord scissors.
- Stop watch/Apgar timer.
- Stethoscope.
- Thermometer.
- Bedside blood glucose measuring device.

i) Every resuscitation unit (as opposed to simple infant warmers in the delivery rooms) is equipped with its own oxygen/compressed air outlets, as well as an oxygen blender and a pulse oximeter.

j) Transcutaneous oxygen saturation measurements to monitor oxygen application in the delivery room should always be preductal by applying the sensor to the right hand or right lower arm. This is in contrast to the later measured postductal SaO_2 to rule out congenital heart defects[112].

k) Adequately trained personnel can also use a T-piece resuscitator (i.e. Neo-Puff/Perivent®) on the resuscitation unit. Because this device needs a good instruction and regular use to be applied safely and efficiently, it is mandatory to always have a ventilation bag with the necessary equipment (mask, tubing system, connectors) on each resuscitation unit.

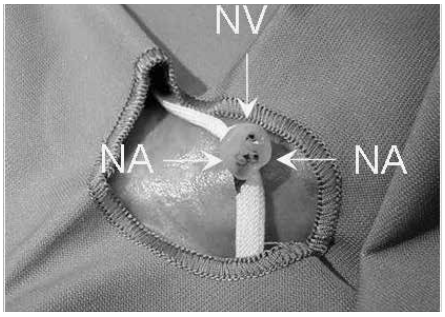

Figure 7: Vessels of the umbilical cord

Figure 8: Introduction of the umbilical venous catheter (UVC)

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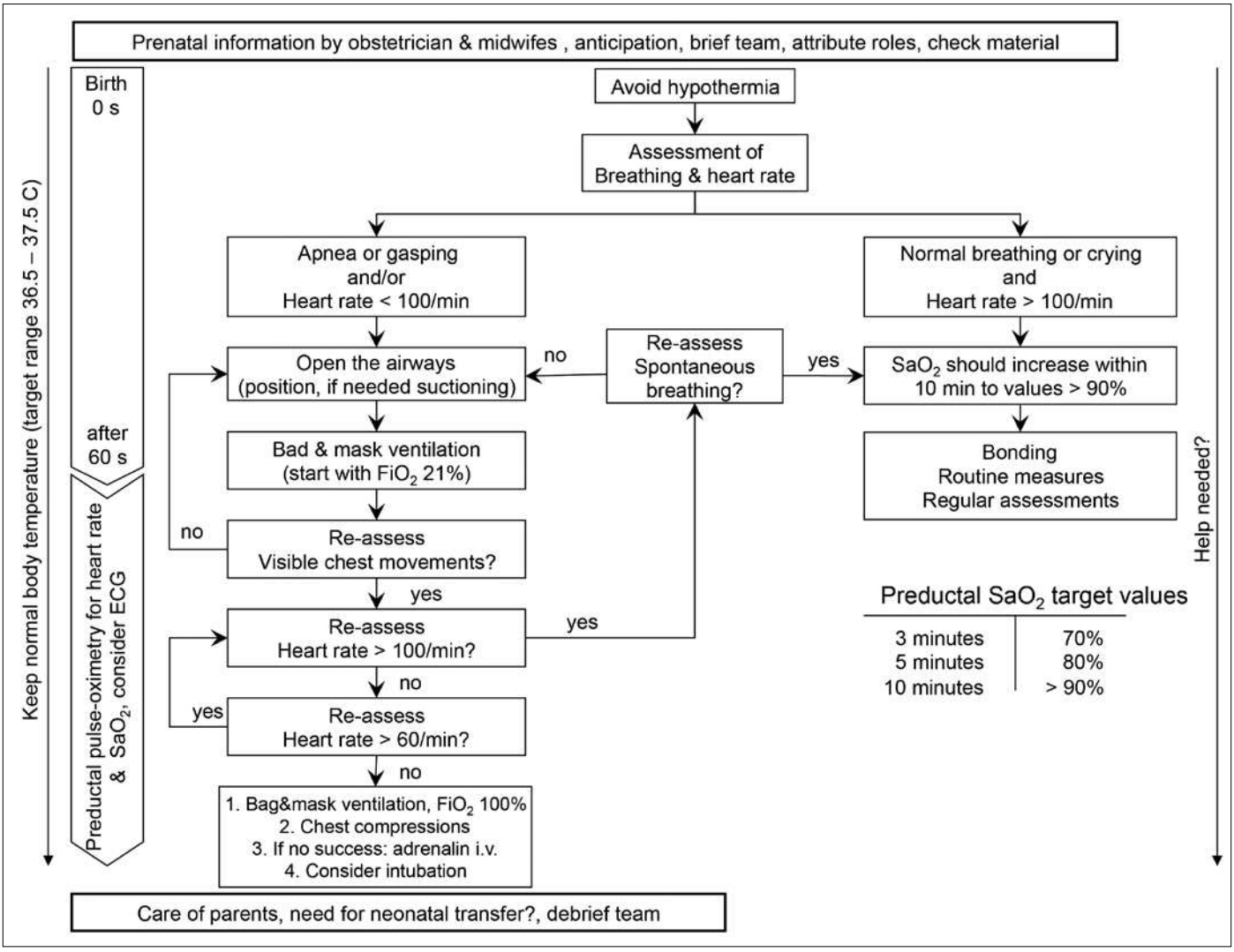

Algorithm: Support of adaptation and resuscitation of the newborn infant